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USE OF REMOTELY SENSED DATA FOR HYDROLOGIC INVESTIGATIONS IN WOOD BUFFALO NATIONAL PARK

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SUMMARY

LANDSAT multi-spectral scanner (MSS) digital data were purchased from the Prince Albert Satellite Station. MSS data were digitally classified into eight cover types using a Fast Parallelepiped Classifier. Principal component analysis and a Taylor enhancement were explored as means of image enhancement. The Taylor enhancement created the best separation of a variety of wetland features. Directional filtering of the image did not generate useful data. NOAA thermal data were investigated as a means of locating large volume discharge areas. Results were negative.

Recommendations for further work include: a need for better ground data; use of thematic mapper digital data; and the use of a Geographic Information System (GIS) to combine and manipulate a variety of data sources.

TABLE OF CONTENTS

	Page
SUMMARY	i
LIST OF FIGURES	iii
LIST OF TABLES	iii
1 INTRODUCTION	1
2 OBJECTIVES	2
3 METHODOLOGY	2
3.1 Directional Filtering	4
3.2 Land Cover Classification	4
3.3 Digital Enhancement	5
3.4 Geometric Correction	5
3.5 Creation of Colour Transparencies and Prints	5
4 RESULTS	6
5 DISCUSSION	6
6 CONCLUSIONS	9
7 RECOMMENDATIONS	10
8 LITERATURE CITED	11

LIST OF FIGURES

Figure		Page
1	Location of Study Area	2
2	NOAA Thermal Image Classified to Indicate Groundwater Discharge Areas	8

LIST OF TABLES

Table		Page
1	Cover Types and Areas Resulting from Digital Classification of October 2, 1987 Landsat MSS Image	7

1 INTRODUCTION

Wood Buffalo National Park is located on the border of Alberta and the Northwest Territories (Figure 1) and encompasses 44,807 km^2. This study was restricted to the Alberta portion of the park.

Wood Buffalo Park was established in 1922 to protect the last existing herd of free roaming wood bison. It is largely a wilderness park with limited access.

The park consists of flat to gently undulating terrain with a range of elevations of 90 m. This lowland is dissected by the Peace River Valley. The region is bounded in the east by the Athabasca and Slave Valleys and in south and west by the Birch and Caribou Mountain plateaux (Airphoto Analysis Associates 1979).

Wood Buffalo Park lies within Rowe's (1972) boreal forest region. The dominant tree species are white and black spruce (Picea glauca and P. mariana) and jack pine (Pinus banksiana). Larch (Larix laricina), balsam fir (Abies balsamea) and lodgepole pine (Pinus contorta) are frequent or locally abundant. Deciduous species such as trembling aspen (Populus tremuloides), white birch (Betula papyrifera) and balsam poplar (Populus balsamifera) are present in lower numbers. Numerous herb-dominated communities including sedge-grass prairie and peatland are present (Airphoto Analysis Associates 1979).

ARIES II software (DIPIX, Ottawa) was used to analyze Landsat Multi-spectral Scanner (MSS) and NOAA thermal imagery. Analysis was conducted at the Saskatchewan Remote Sensing Centre at the Saskatchewan Research Council (SRC) in Saskatoon.

Remotely sensed data were explored to supply the National Hydrology Research Institute (NHRI) with additional data sources for hydrologic

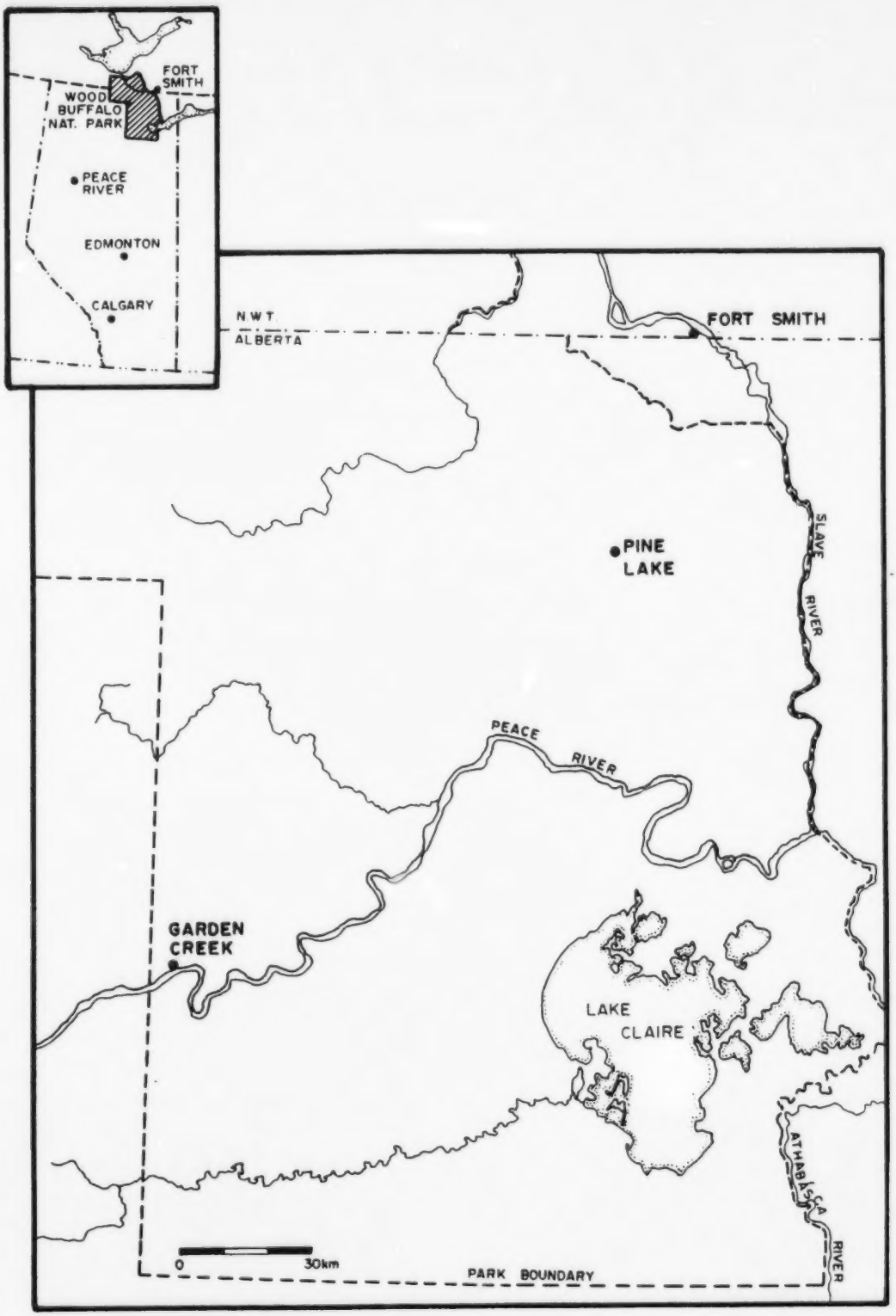

Figure 1. Location of Study Area.

studies in the region.

2 OBJECTIVES

The purpose of the study was to quantify the groundwater recharge and discharge areas in Wood Buffalo National Park.

Specific study objectives were:

a) to select, in collaboration with NHRI Groundwater Division personnel, a suitable image of Wood Buffalo National Park (at the appropriate time of the year, under the best weather conditions to show groundwater recharge and discharge);

b) enhance image data to identify areas of groundwater recharge and discharge. Perform the necessary image analysis, using ground data supplied by NHRI and other sources in SRC's and Parks Canada archives;

c) provide NHRI with a vegetation map and a lineament map derived from satellite imagery of the region;

d) characterize vegetation cover types which may be related to groundwater conditions;

e) prepare a satellite image of the Park. Indicate areas of recharge and discharge, and relative degree of each;

f) explore the use of NOAA thermal data to locate large volume discharges;

g) prepare a report explaining the methodology and rationale for the image analysis.

3 METHODOLOGY

A suitable Landsat MSS image in both colour transparency and computer compatible tape (CCT) form was purchased from the Prince Albert

Satellite Station (PASS) after viewing microfiche at the station.

NOAA - Advanced Very High Resolution Radiometer (AVHRR) was obtained from the Manitoba Remote Sensing Centre's Crop Information archives. Ten dates were inspected to find a cloud free image of the area for the May to June period.

3.1 Directional Filtering

This manipulation is performed using the task referred to as Spatial Filtering By Convolution. The algorithm applies linear filters to feature files (ground feature data) to enhance or suppress spatial features as opposed to spectral or intensity features. The task is used to identify lineaments and fault-lines in a specific direction, chosen by the operator.

Spectral band 7 was subjected to the filtering process. Filters in four directions were used. These included: north-south; east-west; northeast-southwest and northwest-southeast. Results of these filters were presented on the colour television monitor and discussed with the scientific authority.

3.2 Land Cover Classification

The identification of land cover types were accomplished using a combination of tasks. Small areas of known cover type were identified and isolated digitally by the operator. The classification software program called the Fast Parallelepiped Classifier was used to locate and identify areas of similar reflectance. This software program allows the operator to perform an instantaneous classification. Each class is displayed in an unique colour.

3.3 Digital Enhancement

Image enhancement were conducted on all MSS bands, i.e. 4, 5, 6, 7. Digital image enhancement emphasizes radiometric variations within a selected part of a scene at the expense of spectrally different areas of the scene.

A representative "training area" was isolated digitally. This area was chosen from a known karst (discharge) area. The reflectance data from the training area was then used in the two part enhancement. The first stage generated transformed features through principal component analysis. This analysis emphasized brightness, greenness, and blueness components (First, Second and Third Principal Components).

Splitting the component analysis into red, green and blue gun features occurred in the second stage of the image enhancement, known as the Taylor Enhancement after its discover. The resulting data can be loaded through the red, green and blue guns of the colour monitor in the order which best displays features or interest in the image.

3.4 Geometric Correction

All digital products were geometrically corrected to the Universal Transverse Mercador System (UTM) using National Topographic Series (NTS) maps. The software program used point locations and their UTM coordinates scattered throughout the image. Points generally number about 20.

3.5 Creation of Colour Transparencies and Prints

A colour transparency of the geometrically corrected, enhanced image was created digitally using a Imapro Quick Colour Recorder (QCR). This camera-like system is capable of producing 8 x 10 inch colour

transparencies or Polaroid prints. A colour print of the raw image was also created using a standard Cybachrome process. The colour print was produced at a scale of 1:250,000 from the standard 1:1,000,000 colour transparency purchased from PASS.

4 RESULTS

An October 2, 1987 image acquired by PASS in 1987 was identified as the most suitable for analysis purposes and subsequently purchased.

The Taylor enhancement of the four band composite of the image proved to be the most informative enhanced product. It was most suitable when the first, second and third components were loaded through the red, green and blue guns respectively.

Directional filtering of band 7 in north-south, east-west, northeast-southwest and northwest-southeast directions were generated. Collaboration with the scientific authority indicated that these products did not provide useful data to this project.

Digital classification of the Landsat image resulted in outlining eight cover types. These are summarized in Table 1.

The use of NOAA thermal (temperature) data was explored. A colour classification was generated using a digital slicing colour method (Figure 2).

5 DISCUSSION

The accuracy of the digital cover classification is limited by the constraints of the ground data. Ground information were few and training area data relied heavily on the operators limited experience with northern Alberta terrain. Further ground information is required to

Table 1. Cover Types and Areas Resulting from Digital Classification of October 2, 1987 Landsat MSS Image.

Class No.	Description	Area (Hectares)	Percent of Total
1	Water bodies	24,055	0.9
2	Wetlands	70,617	2.8
3	Forest cover	512,417	20.2
4	Slopes	536,275	21.1
5	Sparse vegetation	266,145	10.5
6	Rock outcrops	365,163	14.4
7	Lake fringe	52,961	2.1
8	Water body (deep)	73,073	2.5
Total Classified		1,890,706	100.0

Note: 25% of the image remains unclassified.

Figure 2. NOAA Thermal Image Classified to Indicate Groundwater Discharge Areas.

more accurately define the cover types useful in determining water recharge and discharge areas.

In lieu of air photo analysis a one day over flight in the area could be used to gather additional data on cover types. This data is particularly required to further identify wetland types. This method uses real time data, it is rapid, inexpensive (see Section 7). It does not rely on the availability of expensive recent, high quality air photo cover at a suitable scale.

Should the over flight method be employed colour prints of the satellite image at a suitable scale (1:50,000) should be purchased and used during the flight.

The present study found the images derived from the Taylor enhancement provided the most informative image. A colour transparency of the enhanced study area was created and provided to the NHRI scientific authority for visual interpretation and analysis.

A digital classification derived from analyzing both the colour classification and the thermal NOAA imagery should now be transferred to a GIS for further manipulation.

6 CONCLUSIONS

Landsat MSS satellite image data can be used to digitally classify the regional cover types provided suitable ground data is available. More site specific ground data is required for the region. Specialized enhancements were useful in increasing the visibility of feature differences. Final assessment of the enhanced product now lies with the scientific authority at NHRI.

MSS imagery can provide a general impression of the area and does

identify a number of wetland types. Its relatively low resolution (as compared to the Thematic Mapper data - 80 m versus 30 m) and its lack of fine spectral sensitivity (compared to the Thematic Mapper data) limit its usefulness.

The use of a Geographic Information System (GIS) should be investigated in order to combine and manipulate different data sets. Satellite data is already in useable raster form while some data sets would have to be digitized prior to use. The GIS system used at SRC allow the incorporation of both site specific and more regional data.

7 RECOMMENDATIONS

1) Plan and conduct a single over flight in the area prior to further analysis of the satellite data. Cost of the flight is estimated at two man-days (recorder/navigator and observer + 12 hours aircraft time at $185.00/hour). The total cost is $3,240.00.

2) The purchase and use of Thematic Mapper data should be explored as a means of increasing the effectiveness of the satellite data in land cover classification and in identifying recharge and discharge areas.

3) The combining of various levels and kinds of geographic data should be explored. This could best be done through the use of a Geographic Information System (GIS). This would allow the interactive study of remotely sensed data and more conventionally obtained data, i.e. terrain, geological, cultural, etc. The estimated cost is $5,000.00.

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